Space Weather Technical Forecast

Issued on Thursday, 13 July 2023 at 13:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares likely (R1-R2 Blackouts). Chance of G1/Minor Storms day 1-2 (13-14 Jul).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with peak flare C9.3 from AR3372 in the northeast disc. This is a large region and has produced a number of C-class flares in the period, with a small delta spot in its complex trailer. AR3363 in the southern centre disc is the other large region on the disc, but as a mature spot is much less active. This does have potential instability however, with a delta spot within its large penumbral area and a further penumbral region to the south of the main spot with reverse polarity umbra. The other regions are generally smaller, simpler and stable and giving at total of eight regions on the disc. No Earth-directed CMEs were observed.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by ACE/DSCOVR, was indicative of slow wind conditions, with wind speeds between 290-350km/s. The density was below or around average. Total magnetic field strength (IMF, Bt) has been weak to moderate throughout, mainly below 8nT, whilst the north-south component was initially negative (southward), with minimum -7nT, becoming mainly positive from 13/1800 UTC with maximum 7nT. Phi angle has been predominately positive (away from the Sun), but with a period of neutral orientation from 12/1800-13/0200. Geomagnetic activity has been at Quiet throughout (Kp 0-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been at background. High energy electron flux (greater than 2MeV) was Background to Moderate, peaking 797 pfu at 12/1535 UTC. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a steady trend. A fluence of 1.48e7 pfu was recorded at 13/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to Low activity expected, with an ongoing likelihood of M-class fares and a slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: There are two potential CME arrivals, however both are low confidence. The first would be the late arrival of a CME from the 10 Jul, which was anticipated 13/0600 UTC. This is likely to be followed by a further glancing arrival around 14/1600 UTC from the filament eruption off the south disc on the 11 Jul. The bulk of this CME is expected to miss, however a glancing impact is possible. Earth is also likely to connect to the fast wind of CH23 either late day 1 or day 2 (13-14 Jul), although the strength of this connection is also uncertain. This results in a low confidence geomagnetic forecast. Quiet conditions at first are likely to become Unsettled to Active, with a chance of G1/Minor Storms, especially with any CME arrivals. Activity then easing day 3 onward to mainly Quiet with Unsettled spells.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur. High energy electron flux (greater than 2MeV) is likely to remain at Background to Moderate day 1-2 (13-14 July). Any CME or CH HSS arrival is then likely to enhance flux values, once the initial solar wind pressure eases later in the period, giving a chance of Moderate to

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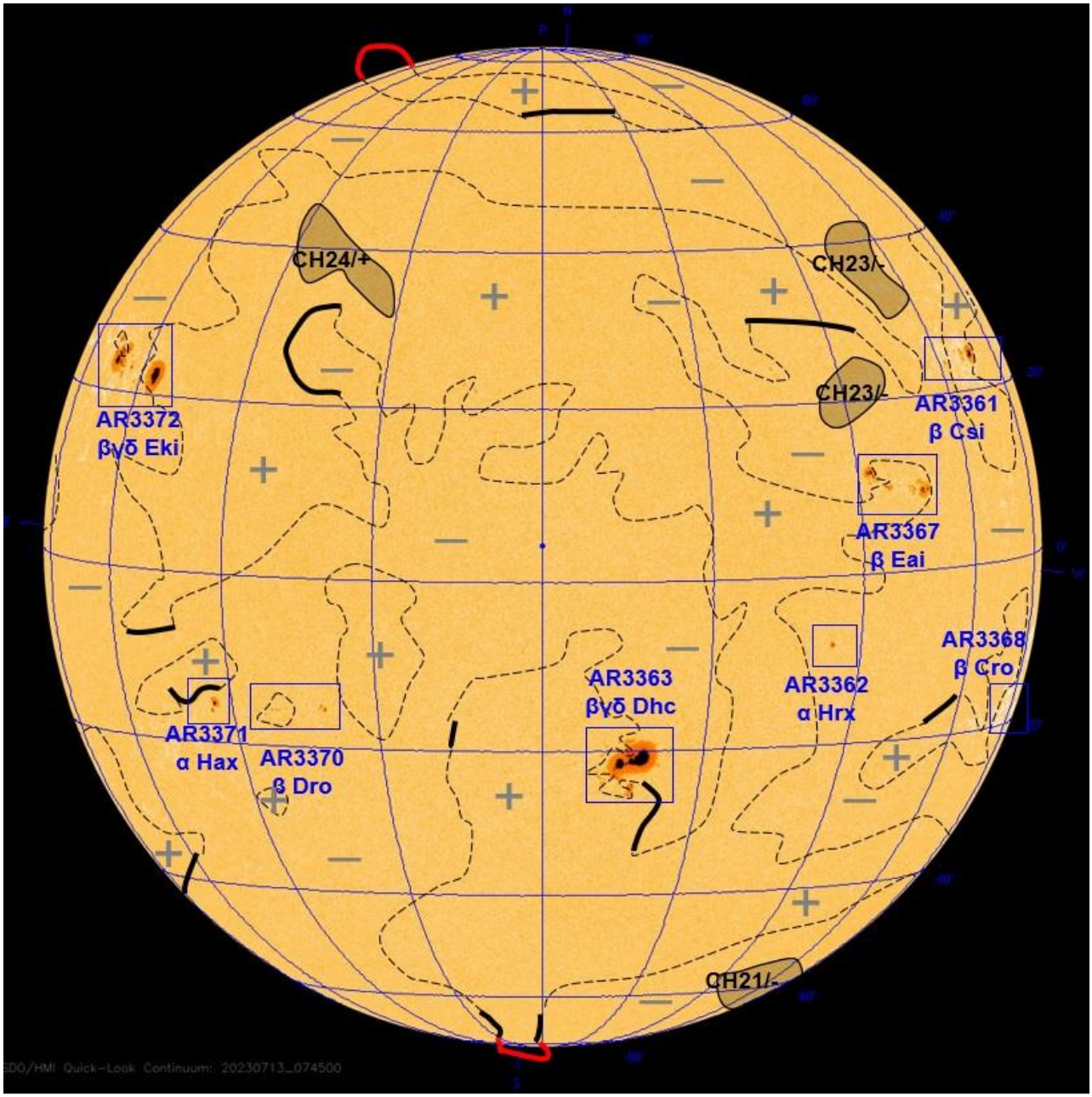
High levels later day 3 or 4 (15-16 Jul). Electron fluence is expected to remain below the Active threshold (1e8 integrated pfu) for much of the period, but with a chance of rising above by the end of day 4 (16 Jul).

Figure 1. Solar Analysis Valid 13/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two low confidence CMEs in the forecast. The first, from the M2 flare on the 10 Jul, was anticipated to give a glance around 13/0600 UTC, but has either missed or will arrive later on day 1 (13 Jul) with a likely weaker impact. A further CME is then likely to arrive 14/1600 UTC, originating from a filament eruption across the southern disc. The bulk of the material is expected to pass to the south of Earth, but with a glancing impact possible.

There is also a low confidence coronal hole fast wind anticipated to arrive either later on day 1 or early day 2 (13 or 14 Jul). On the previous rotation a strong connection occurred with solar winds peaking over 600km/s, however the CH appears much more reduced and fragmented on this occasion. Enlil indicates a weaker connection on day 2 (14 Jul) to around 500 km/s, albeit contaminated with the CME arrivals. Any solar wind enhancement is then expected to ease day 3 onward.

Overall, this gives low confidence to the geomagnetic forecast with current Quiet conditions expected to prevail until any enhancement occurs later day 1 or early day 2 (13 or 14 Jul), increasing to Unsettled to Active, but with a chance of rising to G1/Minor Storms, mainly with any CME arrival. There is a very low chance of G2 Moderate storms on day 2 (14 Jul), most likely if the arrivals combine into a larger single arrival. Activity then easing to Quite to Unsettled through day 3 (15 Jul).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	30	10	1
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/1107	Partial Halo + Halo Shock	M2 AR3366	SW	900 km/s	13/0600 UTC -6/+9hrs	Not yet arrived. Glancing impact Low confidence
11/2335	Partial Halo + Asymmetric halo shock	Filament S of AR3363	SE	870 km/s	14/1600 UTC +/-9hrs	Glancing impact. Low confidence.

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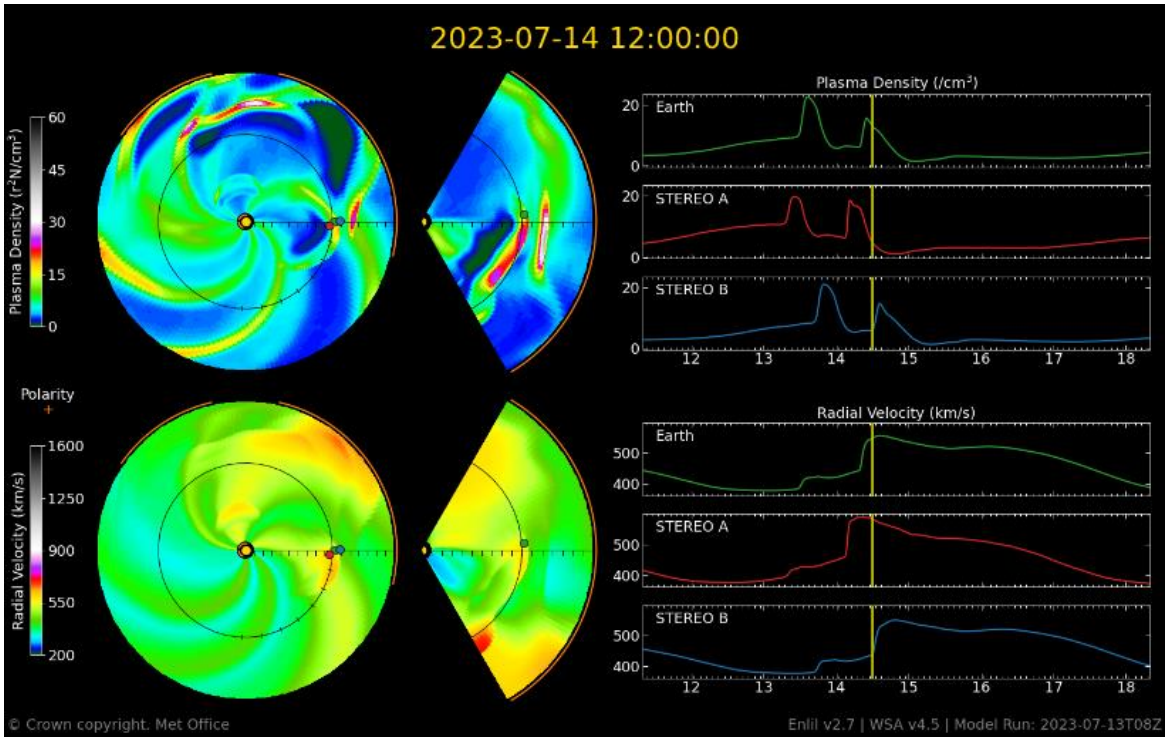
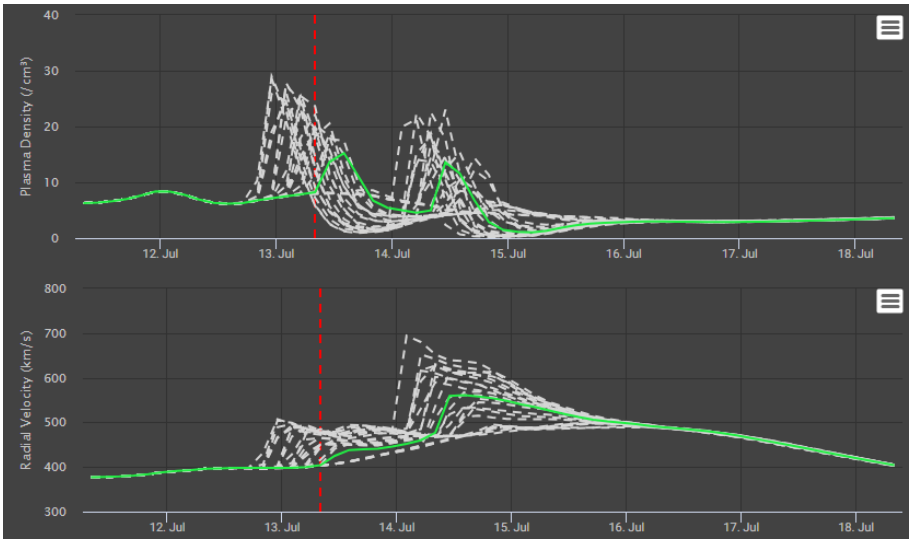
Figure 2: Enlil showing potential CME arrival with ensemble Has an earlier arrival of 2nd CME, however CH HSS is stronger in enlil space than currently expected, and so arrival delayed compared to this model.





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Radio Blackouts - X-Ray Flares:

Activity is currently Low, and is expected to be Low to Moderate through the period with an ongoing likelihood for M-flares and a slight chance of X-flares. There are eight sunspot regions currently on the visible disc, including two large sunspots that have the potential for notable flare activity.

AR3372 near the northeast limb was the source of three R2 flares on the 11-12 Jul, and despite a recent lull in activity still exhibits a complex trailer portion that includes a small delta spot. AR3363 just west of the southern centre disc has remained an inert and mature spot dominated by a large symmetric negative polarity penumbral with two strong umbrae cores. Despite its inactivity, there is also some complexity across the region including a delta spot within the northern portion of the large penumbra, along with a further penumbra region to the south of the main spot consisting of further weak mixed polarity umbra. With the strong field and relatively complex structure, there is the potential for M or perhaps X-flares, despite its lack of current flare activity. The other regions on the disc are all smaller and simpler, and either stable or showing signs of decay.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	70	70	60	60
Very Active	R3 to R5 X Class	No	15	15	10	10

Figure 3: GOES-16/18 X-ray Flux

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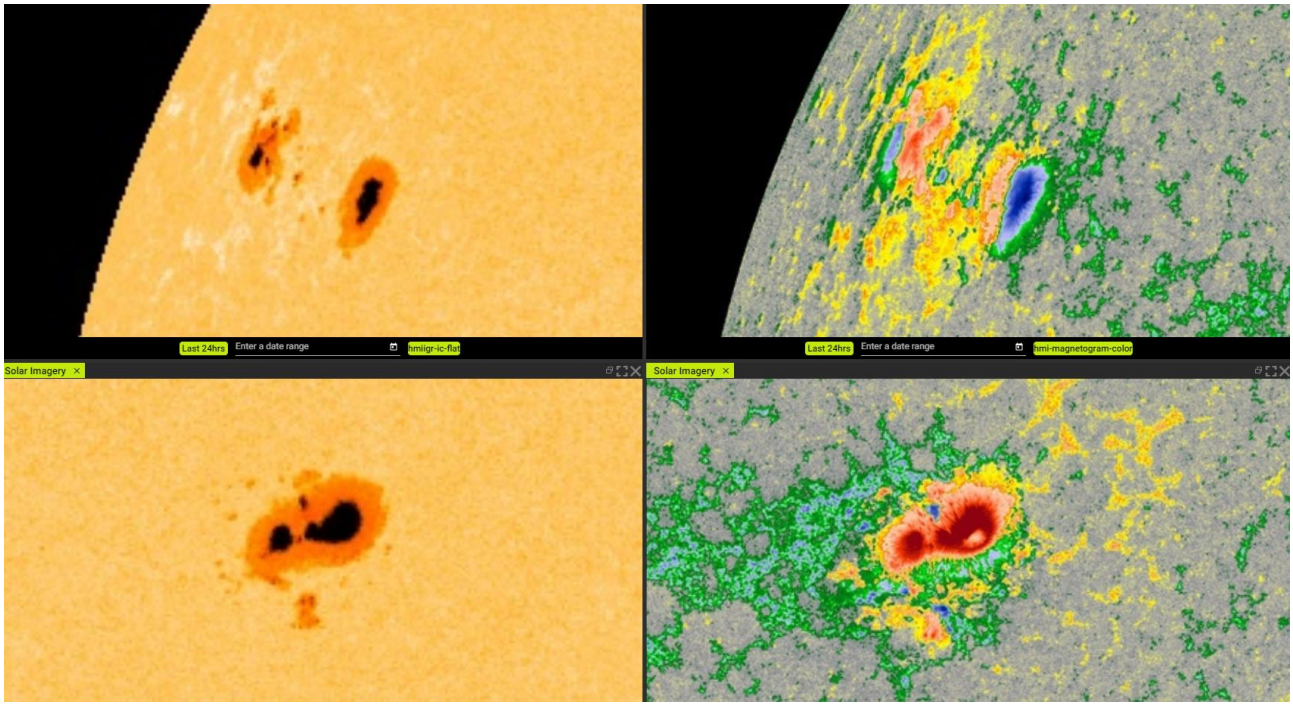
Figure 3b: SDO hmi-intensitygram (left) and magnetogram (right) of AR3372 (top) and AR3368 (bottom)



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently near background and is likely to remain at this level. There is a chance of this rising towards the S1 Minor Radiation storm level, with a slight chance of exceeding, given any significant flaring from the large number of spots on the western disc. This most likely to come from AR3363 as it moves into the western disc, or any of the other smaller regions currently approaching the western limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GEO is varying diurnally between Background and Moderate levels. The next influx of electrons into the Van Allen belt is expected to occur with the combined effect of the CME arrivals and the potential CH enhancement on 13 and 14 Jul. Once any initial solar wind pressure eases from any of these enhancements the observed flux is expected to rise to Moderate, perhaps High levels, mainly day 3 or day 4 (15-16 Jul).

The associated 24 hour fluence is expected to remain below the Active threshold (1e8 total flux), with REFM giving a good guide in the absence of any enhancement. However, any CME or CH arrival results in REFM being unreliable later in the period. Fluence is expected to rise in response to either of these, with a slight chance of breaching the Active level by the end of day 3 (15 Jul) and more likely day 4 (16 Jul).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES-16 >2MeV Electron flux and associated fluence with REFM and recurrence

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